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POLYMER COMPOSITE PACKAGING FILM FOR FRESH MEAT AND  
VEGETABLE PRODUCE

Related Application

This application claims the benefit of U.S. Provisional Patent Application No. 60/166,659, filed November 19, 1999.

Technical Field

This invention relates to packaging films for fresh meat and vegetable produce and, in particular, a polymer composite packaging film that is formulated to have a film surface with anti-fog properties and a controlled gas permeability rate.

Background of the Invention

Optically transparent films useful for covering food product containers and packaging food products are ideally formulated to provide consumers with a clear view of the packaged food product while maintaining its appearance and freshness. Films with oxygen transmission rate (OTR) control properties extend the shelf life of refrigerated freshly cut produce and fresh meat since the presence of either too much or too little oxygen in the package lowers shelf life. For example, in the packaging of lettuce, excessive oxygen in the package results in enzymatic browning of cut surfaces of the lettuce. On the other hand, insufficient oxygen in the package results in lettuce spoilage caused by anaerobiosis. Similarly, fresh meat packaging denies delivery of excessive oxygen to the meat to minimize bacterial growth and simultaneously permits delivery of sufficient oxygen to the myoglobin contained

within the meat to maintain its natural red color and thus achieve the fresh looking product preferred by consumers.

Optically transparent films with anti-fog properties provide a clear, unobstructed view of a food product. Fog arises in the presence of surface moisture on the packaging film. Sources of such moisture include ambient moisture in the atmosphere and latent moisture in the packaged product.

Packaging films made from polyvinyl chloride (PVC) have been used for decades to wrap red meat and produce. Examples of such PVC films include Vitafilm™ packaging film sold by Pliant Corporation, Uniontown, Ohio and Resinite™ packaging film sold by AEP, Inc., Hackensack, New Jersey. PVC films possess a sparkling clear view of the packaged product, and, when formulated with tackifier plasticizers, exhibits superb cling properties. While packaging films made from olefinic materials can be formulated to control OTR, they are susceptible to surface moisture buildup in the form of small beads that obscure a consumer's view of the product contained in the package. An example of such an olefin film includes Cryovac™ packaging film sold by Sealed Air Corporation, Hartford, Connecticut. Reducing the surface moisture buildup in olefinic films by adding standard anti-fog agents has been largely unsuccessful. The reason is that the anti-fog agents are difficult to contain within the film because they tend to wash off. The anti-fog agents also interfere with other film surface properties of the olefinic film making it difficult to print and seal.

It would be desirable, therefore, to have available an optically transparent packaging film with minimal susceptibility to surface moisture accumulation and a controllable OTR.

#### Summary of the Invention

An object of the present invention is to provide a visually clear atmospheric packaging film for refrigerated fresh meat and freshly cut produce to prolong their states of freshness.

The present invention is a polymer composite film for packaging fresh meat and vegetable produce. The composite film is of a particular thickness and is

compounded to have a film surface with visual clarity and gas permeability rate (specifically OTR) control.

In a first preferred embodiment of the present invention, a monolayer composite film includes a polymer film substrate, *e.g.*, PVC, into which one or  
5 more surface active agents are incorporated to provide the composite film with anti-fog properties. The PVC film substrate readily absorbs the surface active agents, which have an affinity for moisture. The surface active agents evenly spread minuscule beads of any moisture coating the inner surface of the package and thereby present a visually clear surface through which a customer can inspect the  
10 packaged product.

To provide the composite film with controllable OTR, one or more plasticizer active ingredients are incorporated into the PVC film substrate. The amount and type of plasticizer dictate the degree of stiffness of the composite film, and, for a given thickness or gauge of the composite film, an increase in plasticizer  
15 provides an increase in OTR. Control of OTR is governed not only by the amount and type of plasticizer but also by the orientation of the molecular chain order of the PVC film substrate used in the composite film. Applying heat and/or imparting stretch forces to the composite film affects the OTR because heat and stretching affect the molecular chain orientation. OTR preservation of a monolayer composite  
20 film is, therefore, maintained by sealing without shrinking or stretching the composite film as it is applied to a container or formed into a package container.

In a second preferred embodiment of the invention, a multilayer lamination or extrusion of PVC films provides OTR control at a fixed composite film gauge. In a first implementation, at least two layers of PVC films having different OTR  
25 properties are separated by an adhesive layer and fused together. In a second implementation, multiple layers of PVC film having different OTR properties are extruded together in a molten state without an adhesive. In a third implementation, multiple layers of PVC film having different OTR properties are laminated together under high temperature and pressure. Each of the three implementations provides a  
30 multilayer composite film having a specified overall OTR at a prescribed overall film thickness.

In a third preferred embodiment of the invention, a multilayer lamination or extrusion can be formulated using layer distribution to provide a differential heat seal.

5 Additional objects and advantages of this invention will be apparent from the following detailed description of preferred embodiments thereof which proceeds with reference to the accompanying drawings.

#### Brief Description of the Drawings

10 Fig. 1 is a graph showing the relationship between OTR and plasticizer material concentration for a monolayer composite PVC film of a specified thickness.

Fig. 2 is a graph demonstrating the effect of the orientation of the molecular chain order of the PVC film on the plasticizer concentration versus OTR @ 1.0 mil curve.

15 Fig. 3 is a table showing certain properties of exemplary monolayer PVC films implemented in accordance with the present invention.

Fig. 4 is a table showing trial test data representing 11 two-layer sample laminations of different gauges and film layer component types, as identified in Fig. 3.

20 Fig. 5 is a set of two curves showing OTR @ 1.0 mil thickness expressed as a function of di(2-ethyl-hexyl adipate) (DEHA) equivalents for monolayer composite films made with high and low concentrations of epoxidized soya oil (ESO) in accordance with the present invention.

Fig. 6 is a table showing the formulation of a preferred monolayer PVC film made in accordance with the present invention for fresh cut produce.

#### Detailed Description of Preferred Embodiments

25 A first preferred embodiment of the invention is a monolayer polymer composite film that comprises a PVC substrate into which a surface active agent and a plasticizer material are incorporated. A PVC material in powder form, one or more surface active agents in liquid or solid form, and a plasticizer material in solid  
30 or liquid form are dry blended. The resultant blend is extruded into a film sheet or into pellets that are then extruded into a film sheet. The surface active agent is

thereby homogeneously mixed in the polymer matrix. The homogeneous mixture promotes uniform spreading of any surface moisture present on the composite film when in use and thereby maintains its visual clarity.

5 The amount of surface active agent preferably ranges from between about 0.001 and 5 parts/hundred resin, the higher proportion of surface active agent providing a slippery surface to the composite film. Although the PVC material, which is a polar compound, readily absorbs surface active agents, skilled persons will appreciate that there is an upper limit to the amount of surface active agent that PVC can accept. Preferred surface active agents include surfactant, antistat,  
10 antiblock, and slip agents.

The amount of plasticizer material or materials preferably ranges from between about 5 and 60 parts/hundred resin. For a given gauge of the PVC film substrate, an increase in the amount of plasticizer increases the OTR. Fig. 1 shows the relationship between plasticizer material concentration, expressed in DEHA  
15 equivalents, and OTR for a 1.0 mil thick monolayer composite PVC film. Equivalent DEHA is a measure of the amount of plasticizer or plasticizer blend required to give the same amount of stiffness as that provided by a unit measure of DEHA. Curve 12 represents an exponential trendline derived from the calculated data appearing in Fig. 3 substituted into the exponential equation  $y = 25.628e^{0.0879x}$ .  
20 The diamond-shaped symbols indicate experimental data points. The x and y variables represent equivalent DEHA and OTR @ 1.0 mil thickness, respectively, and the parameter  $R^2$  represents a statistical measure of confidence that the equation fits the data presented.

The OTR selected for commercial use depends in part on the type of product  
25 that is to be packaged. A higher OTR (*e.g.*, 600 and greater cc/100 in<sup>2</sup>/day) is preferable to maintain the redness of red meat, and a lower OTR (*e.g.*, 120 and below cc/100 in<sup>2</sup>/day for romaine lettuce; 120-210 cc/100 in<sup>2</sup>/day for fresh cut salad; and 240-360 cc/100 in<sup>2</sup>/day for coleslaw salad) is preferable to maintain crisp, fresh salad. Preferred plasticizer materials include di(2-ethyl-hexyl) adipate  
30 (DEHA) and epoxidized soya bean oil (ESO). ESO is a secondary plasticizer used in flexible systems at low levels to add stability and to produce a cost-effective film.

Other factors affecting OTR include the gauge (*i.e.*, thickness) of, molecular orientation of, and temperature applied to the composite film. Fig. 2 is a set of two curves 20 and 22 showing that the orientation of the molecular chain comprising the PVC film substrate shifts the plasticizer concentration versus OTR curve along the ordinate axis. Curve 20 represents an exponential trendline of  $y = 68.304e^{0.0418x}$  or a 1.0 mil oriented composite PVC film. Curve 22 represents an exponential trendline of  $y = 37.954e^{0.0743x}$  for a 1.0 mil nonoriented composite PVC film. Thus, curves 20 and 22 represent composite films having the same range of plasticizer composition but with different molecular orientations. Orienting a monolayer PVC composite film can be achieved by prestretching the composite film and thereby increasing the order of the molecules in the molecular chain. The amount and direction of the recovery of the prestretching imparted to the composite film may be tested by measuring shrinkage at high temperature. The shrinkage data points are used to derive curve 20. Thus OTR control and its preservation for a PVC-oriented composite film may be achieved by refraining from shrinking or stretching the composite film when using it to cover a container or forming it into a package container.

Temperature also affects the OTR of the composite film. An increase or decrease in temperature applied to the composite film causes a consequent increase or decrease in its OTR.

Non-resin additives are added to the film composite to change the physical characteristics of the resin. For example, plasticizers have a dual effect on the PVC resin; by intimately associating themselves with the PVC resin powder, they (1) change the consistency of the melted and cast PVC film from a stiff, hard, brittle thermoplastic film resembling glass to a soft, rubbery, tough, stretchable film and (2) change the permeability of the film so that the gas permeability rate increases, thereby providing OTR and moisture vapor control. Exemplary non-resin additives include polyoxyethylene sorbitan monooleate (POE-SMO), an anti-fog agent; glycerol monooleate (GMO), an anti-fog agent; and sorbitan monostearate (SMS), a slip agent.

Process aids and copolymers may also be introduced into the PVC resin film, as is commonly known to those skilled in the art. Process aids improve the machinability of the film by acting as external and/or internal lubricants that modify the polymer melt. External lubricants allow the film to slide over without sticking to the hot metal components of the film manufacturing equipment. Internal lubricants provide lubrication between the individual polymer chains to allow internal slippage that promotes heat stabilization and thereby prevents tearing of the polymer chains and melt fracturing of the film. Examples of external lubricants include polyethylene wax, erucamide, and ethylene bis-oleamide (EBO). Stearic acid is an example of an internal lubricant. Calcium/zinc heat stabilizer soaps are process aids that may act as internal and external lubricants. The amount of process aid material or materials preferably ranges from between about 0.001 to about 5 parts/hundred resin. Copolymers can be used to modify the existing properties of the polymer to allow maximization of its beneficial characteristics. Exemplary copolymer functions include increasing the strength and modulus of the film while increasing its softness. Further, copolymers can act as surface active agents, aid in heat sealing, or function as a process aid by affecting viscosity, as is commonly known to those skilled in the art. Skilled persons will recognize that use of copolymers does not appreciably affect OTR and thus does not materially affect the method of determining a plasticizer equivalent described in Fig. 5 below. Exemplary commonly known copolymers include polyvinyl chloride polyvinyl acetate (PVCPVA) and polyester adipate.

Fig. 3 is a table showing certain properties of exemplary monolayer PVC films in which the invention has been implemented. Fig. 3 presents values of certain properties for different gauges of different base film types. Film styles identified as CBIX, BIX, FTX, MX, LGS, LG, and PS are Vitafilm™ packaging film products. CBIX and BIX indicate, respectively, Canadian- and German-produced biaxially oriented general purpose films; FTX indicates biaxially oriented shrink films; LG and LGS indicate delicatessen food style wrapping films; LG also indicates laundry bundling wrapping films; Omnifilm™ indicates meat wrapping films; MX indicates oriented meat wrapping; and PS indicates print films. Film

styles identified as AV are Vitafilm™ variants that are not currently commercially available.

The films described in Fig. 3 were made in accordance with the following procedure. PVC resin powder was dry blended in a high intensity blender, *e.g.*, a  
5 "Henschel blender" made by Henschel Corp., at high speed at a temperature sufficient to allow absorption of the non-resin additives into the PVC resin particles. Non-resin additives, *e.g.*, plasticizers, process aids, slip agents, anti-fog agents, and surface active agents, were added gradually to the highly porous PVC resin powder during dry blending. Spraying the non-resin additives onto the PVC resin as the resin warms  
10 in the high intensity blender constitutes one method of performing this addition. After introduction of the non-resin additives was complete, the resulting dry blend was placed into a cooling blender that feeds into an extruder having controlled temperature and speed. While in the extruder, the dry blend melted and became a visco-elastic melt. The melt was then forced into a die producing pellets that were fed into a  
15 second extruder with a die that produced a thin film. The use of two extruders resulted in more complete mixing, permitted increased control of production rates, and allowed reworking of scrap trim remnants, thereby increasing cost-effective and efficient manufacture. This production process resulted in a thin film of specified thickness that was wound onto cylindrical cores as rolls of specified length and width.  
20 An alternative process commonly known to those skilled in the art involves forcing the visco-elastic melt into a first extruder with a die producing a thin film.

In Fig. 3, the nominal gauge is expressed in mils (0.001 in.). Equivalent DEHA is a measure of the degree of stiffness of the film and is expressed relative to the amount of plasticization by DEHA. In Fig. 3, the greater the plasticizer  
25 concentration, the softer the resulting film. The OTR based on a 1.0 mil (0.025 mm) thick film, which may be called "permeance," shows the effect of plasticizer contribution to the OTR of the composite film. Molecular Orientation (shrink) refers to the degree of order imparted to the composite film. Slip, anti-block, anti-fog, surface active agents, and plasticizers are all non-resin additives that were added to the  
30 PVC resin as described above.



A second embodiment of the invention is a multilayer lamination of PVC films having different OTR properties to give a specified overall OTR for a multilayer composite PVC film at a specified thickness. This embodiment accommodates a need for a predictable OTR when the film gauge is a fixed parameter. The adjacent  
5 surfaces of the PVC layers can be separated by a material, which may be either a tie adhesive or barrier adhesive with minimal effect on OTR, or air. Air may be considered an adhesive because PVC adheres to itself due to the magnitude of its binding attractive force.

Fig. 4 is a table showing trial test data representing 11 two-layer sample  
10 laminations of different gauges and film layer component types, such types identified in Fig. 3. The adhesive type (Liofol No. 7980) used for trials A, B, C, D, E, F, G, H, I, J, and K is a solid adhesive with minimal effect on OTR. The 2-ply Nominal Gauge refers to the thickness of the two-layer laminations, expressed in mils. Fig. 4 shows that two-layer PVC films of approximately the same nominal thickness can be  
15 produced with different OTR values. For example, the films represented by trials D and E are each 2.00 mils thick but have respective OTR values of about 75.2 cc/100 in<sup>2</sup>/24 hours and about 138.4 cc/100 in<sup>2</sup>/24 hours.

The 11 two-layer sample laminations described in Fig. 4 were made in accordance with the following procedure. Each individual film was produced using  
20 the procedure described above. One film was designated as the primary web and the other the secondary web. The primary and secondary webs constituted, respectively, the back side and the seal side of the two-layer packaging film. Skilled persons will appreciate that either film could constitute the primary or secondary web. For example, the primary web constitutes the seal side and the secondary web constitutes  
25 the back side in the production of a printed two-layer packaging film. The primary web was covered with an adhesive, and the secondary web was laminated to the adhesive-coated primary web. Alternatively, the primary web could be coated with adhesive, and the secondary web could be joined to the primary web using a pinch roller. Finally, additives were introduced to begin a curing process, as is known to  
30 those skilled in the art. The curing process reached completion upon winding of the packaging film around a cylindrical cord to achieve a specified length and width.

The conventional lamination method used entails dissolving the adhesive in water or a solvent and then coating the primary web with the liquid adhesive mixture. The coated film is then dried to remove the solvent. Once substantially all of the solvent has been removed, the secondary web is joined to the coated primary web.

5 However, various laminators and adhesives are known to those skilled in the art including Uteco™ laminating manufacturing equipment and Lyofol™ adhesive. For example, the packaging film of the present invention has sufficient binding attractive force to allow use of solventless laminators known to those skilled in the art. Solventless laminators offer the benefits of increased production rate, because no

10 drying time is required, and decreased manufacturing cost, because no fumes are released.

Fig. 5 is a set of two curves showing the OTR @ 1.0 mil thickness expressed in DEHA equivalents for the base film laminants set out in Fig. 6. Curves 50 and 52 represent OTR @ 1.0 mil thickness trendlines for monolayer films with, respectively,

15 high and low ESO relative concentrations as a function of DEHA. An ESO/DEHA ratio of greater than 0.5 is considered to be a low ESO concentration, while a ratio of greater than 0.5 is considered to be a high ESO concentration. Fig. 5 also presents exponential equations from which curves 50 and 52 are derived. The equation for curve 50 is  $y = 16.981e^{0.1032x}$ , and the equation for curve 52 is  $y = 42.886e^{0.0773x}$ . The x

20 and y variables represent equivalent DEHA and OTR @ 1.0 mil thickness, respectively, and the parameter  $R^2$  represents a statistical measure of confidence that the equation fits the data presented. The square- and diamond-shaped symbols indicate actual data points.

Fig. 5 demonstrates that a change in Equivalent DEHA results in a

25 corresponding change in OTR. Fig. 5 suggests that an amount of ESO and an equivalent amount of DEHA that provide a specified film stiffness have different corresponding OTRs. A skilled person can use Fig. 5 by selecting a desired OTR for an equivalent film thickness of either a high or low ESO concentration to achieve an equivalent DEHA. As a first example, someone wanting to create a film with an OTR

30 of 400 cc/100 square inches/24 hours and wanting to use a low ESO formula could determine the required amount of plasticizer to be about 28.8 DEHA equivalent. As a

second example, someone wanting to create a film with an equivalent DEHA of 24.00 pphr and wanting to use a high ESO formula could determine the OTR at 1.0 mil to be 202.1. Fig. 5 presented herein provides OTR data curves for a 1.0 mil film, but similar changes in OTR versus Equivalent DEHA would arise with different gauge films.

Fig. 6 is a table showing the proportional formulation of a preferred monolayer PVC film expressed in parts per hundred resin (pphr). Fig. 6 also states the function performed by each component and provides the OTRs at 1.0 mil for each film style.

A preferred two-layer PVC composite film is formulated with 100 pphr of each of the commercially available PVC films, BIX 44-XT and LGS, the properties of which appear in the table of Fig. 3. The formulations of BIX 44-XT and LGS films are either compounded and extruded separately and laminated together with an adhesive or compounded separately and coextruded together.

A third preferred embodiment of the invention is a multilayer lamination or extrusion of PVC films formed to implement layer distribution, which provides differential heat seal capability. This is achieved by forming a composite film that includes a first, inner PVC layer having a lower melting point and a second, outer PVC layer having a higher melting point. Thus there are two layers that have different sealing temperatures. So when a set of seal jaws come together, only the inner layers are melted, rather than both the inner and outer layers, due to the differing melt temperatures of the two layers. This embodiment is especially useful when one is using a stiff and brittle film that will not seal in the absence of a softer inner sealing layer. For example, the Vitafilm™ BIX 44XT/LGS film constituting the preferred second embodiment of the present invention benefits from this differential heat seal capacity since the BIX film is stiffer, with a higher melting point, whereas the LGS film is softer, with a lower melting point.

A differential heat seal is a laminated or coextruded structure in which the inner layer of the film structure functions as a sealant layer and the outer layer functions as a heat transfer layer. The inner layer is the softer, more-susceptible-to-melting layer that seals together the stiffer, less-susceptible-to-melting outer layer. The outer layer therefore gives support to the inner layer and permits application of

heat to the multiple-layer structure without necessarily melting the outer surfaces. A common example of the implementation of a differential heat seal is a bag for snacks (*e.g.*, peanuts, potato chips, or pretzels). The stiffer outer layer of the bag seals shut because the less stiff inner layer with a lower melting point melts together at a sealing  
5 seam. The two-layer composite film can be formed by conventional multilayer coextrusion or lamination techniques, or a combination of them. The composite film provides different heat sealability and displays the structural integrity of low temperature PVC materials but also has a controllable OTR.

10 It will be obvious to those having skill in the art that many changes may be made to the details of the above-described embodiments of this invention without departing from its underlying principles.